CLAIMS

We claim:

1. A method for making a superdirective circular receive array with an odd number of elements comprising:

calculating a minimum array efficiency of the superdirective circular receive array;

calculating a maximum superdirective gain of the superdirective circular receive array;

determining an amplitude weight or a phase weight for an array element in the superdirective circular receive array based on the minimum array efficiency and the maximum superdirective gain; and

determining a number of array elements in the superdirective circular receive array and a radius of the superdirective circular receive array.

2. The method of claim 1, wherein angle spacings between elements of the superdirective circular receive array are equal.

3. The method of claim 1, wherein the array efficiency is determined in accordance with an equation

$$\mathrm{Eff} = \frac{\int_0^{2\pi} d\varphi \int_0^{\pi} d\vartheta \sin(\vartheta) [w_n]^T \left[g_n(\vartheta, \varphi)\right]^T \left[g_n(\vartheta, \varphi)\right] [w_n]}{\int_0^{2\pi} d\varphi \int_0^{\pi} d\vartheta \sin(\vartheta) \left[g_n(\vartheta, \varphi)\right] \left[g_n(\vartheta, \varphi)\right]^T}$$

where $g_n(\vartheta, \varphi)$ is a complex far-field radiation in direction ϑ, φ, $[w_n]$ is an amplitude/phase weighting of the elements of the superdirective circular receive array, the numerator of the equation representing a noise power coming from a sphere of space from $0 < \vartheta < \pi$ and $0 < \varphi < 2\pi$, and the denominator is a summation of a noise power of each of the elements of the circular array.

4. The method of claim 1, wherein the superdirective gain is determined in accordance with an equation

$$G(\vartheta_o, \varphi_o) = \frac{P(\vartheta_o, \varphi_o)}{\int_0^{2\pi} d\varphi \int_0^{\pi} d\vartheta \sin(\vartheta) P(\vartheta, \varphi)}$$

where $P(\vartheta, \varphi)$ is a far-field power, and $G(\vartheta_o, \varphi_o)$ is defined as a directive gain to be maximized in the desired direction ϑ_o, φ_o, where angles are expressed in a standard spherical coordinate system.

5. The method of claim 4, wherein $P(\vartheta, \varphi)$ is determined in accordance with an equation

$$P(\vartheta, \varphi) = \left| \sum_{n=1}^{N} w_n g_n(\vartheta, \varphi) \right|^2 = \left| [w_n][g_n(\vartheta, \varphi)]^T \right|^2$$

where w_n is an amplitude/phase weighting for an nth element of the circular array and

$g_n(\vartheta, \varphi)$ is a complex far-field radiation in direction ϑ, φ produced by the nth element as determined by a geometrical location of the nth element with respect to a local origin for the circular array.

6. The method of claim 1, wherein an amplitude weight or a phase weight for an array element is determined in accordance with an equation

$$[N_{m,n}][w_n] = G_o[D_{m,n}][w_n]$$

where $N_{m,n}$ is determined in accordance with an equation

$$N_{m,n}(\vartheta_o, \varphi_o) = [g_m(\vartheta_o, \varphi_o)]^T[g_n(\vartheta_o, \varphi_o)]$$

G_0 is the superdirective gain, $[w_n]$ is the amplitude weight or the phase weight, and $D_{m,n}$ is determined in accordance with an equation

$$D_{m,n} = \int_0^{2\pi} d\varphi \int_0^{\pi} d\vartheta \sin(\vartheta) N_{m,n}(\vartheta, \varphi)$$

7. A method for determining an overhead null in synthesized patterns of received signals of a circular array, comprising

receiving signals V_1, V_2, and V_3; and

calculating the synthesized patterns in accordance with the equations

$$
\begin{aligned}
S_A &= V_1 - \frac{V_2 + V_3}{2} \\
S_B &= V_2 - V_3 \\
S_C &= V_1 + V_2 e^{+j2\pi/3} + V_3 e^{-j2\pi/3},
\end{aligned}
$$

where S_A, S_B, and S_c are the synthesized patterns.

8. The method of claim 7, further comprising calculating calibration adjustment correction constants for the received signals.

9. An apparatus for an antenna system, comprising

a plurality of dipole elements located in a circular arrangement of a radius that is less than a detected wavelength to receive a plurality of analog signals, wherein the plurality of dipole elements is an odd number of dipoles;

an analog-to-digital converter to convert the plurality of analog signals to a plurality of digital signals;

a first processor configured to calculate amplitude and phase corrections based on a minimum array efficiency and a maximum superdirective gain; and

a second processor to apply calculated phase and amplitude weights and amplitude and phase corrections to the plurality of digital signals.

10. The apparatus of claim 9, further comprising a memory to store calculated amplitude and phase weights.

11. The apparatus of claim 9, wherein the plurality of short dipoles is 3 dipoles.

12. The apparatus of claim 11, further comprising high-impedance preamplifiers coupled to each one of the plurality of dipole elements.

13. The apparatus of claim 9, wherein the first processor calculates the amplitude and phase weights.

14. The apparatus of claim 13, wherein the amplitude and phase weights are determined in accordance with an equation

$$\left[N_{m,n}\right]\left[w_n\right] = G_o\left[D_{m,n}\right]\left[w_n\right]$$

where $N_{m,n}$ is determined in accordance with an equation

$$N_{m,n}\left(\vartheta_o, \varphi_o\right) = \left[g_m\left(\vartheta_o, \varphi_o\right)\right]^T\left[g_n\left(\vartheta_o, \varphi_o\right)\right]$$

G_0 is the superdirective gain, $[w_n]$ is the amplitude weight or the phase weight, and $D_{m,n}$ is determined in accordance with an equation

$$D_{m,n} = \int_0^{2\pi} d\varphi \int_0^{\pi} d\vartheta \sin\left(\vartheta\right) N_{m,n}\left(\vartheta, \varphi\right)$$

15. The apparatus of claim 9, wherein the first processor also calculates an overhead null in synthesized patterns of received signals of the antenna system.

16. The apparatus of claim 15, wherein the overhead null is determined in accordance with equation

$$
\begin{aligned}
S_A &= V_1 - \frac{V_2 + V_3}{2} \\
S_B &= V_2 - V_3 \\
S_C &= V_1 + V_2 e^{+j2\pi/3} + V_3 e^{-j2\pi/3}
\end{aligned},
$$

where S_A, S_B, and S_c are the synthesized patterns.

17. The apparatus of claim 9, wherein the minimum efficiency as determined in accordance with equation

$$
\mathrm{Eff} = \frac{\int_0^{2\pi} d\varphi \int_0^{\pi} d\vartheta \sin(\vartheta) [w_n]^T \left[g_n(\vartheta, \varphi)\right]^T \left[g_n(\vartheta, \varphi)\right][w_n]}{\int_0^{2\pi} d\varphi \int_0^{\pi} d\vartheta \sin(\vartheta) \left[g_n(\vartheta, \varphi)\right]\left[g_n(\vartheta, \varphi)\right]^T}
$$

where $g_n(\vartheta, \varphi)$ is a complex far-field radiation in direction ϑ, φ, $[w_n]$ is an amplitude/phase weighting of the elements of the superdirective circular receive array, the numerator of the equation representing a noise power coming from a sphere of space from $0 < \vartheta < \pi$ and $0 < \varphi < 2\pi$, and the denominator is a summation of a noise power of each of the elements of the circular array.

18. The apparatus of claim 9, wherein the superdirective gain of the antenna system is determined in accordance with an equation

$$G(\vartheta_o, \varphi_o) = \frac{P(\vartheta_o, \varphi_o)}{\int_0^{2\pi} d\varphi \int_0^{\pi} d\vartheta \sin(\vartheta) P(\vartheta, \varphi)}$$

where $P(\vartheta, \varphi)$ is a far-field power, and $G(\vartheta_o, \varphi_o)$ is defined as a directive gain to be maximized in the desired direction ϑ_o, φ_o, where angles are expressed in a standard spherical coordinate system.

19. The apparatus of claim 18, wherein $P(\vartheta, \varphi)$ is determined in accordance with an equation

$$P(\vartheta, \varphi) = \left| \sum_{n=1}^{N} w_n g_n(\vartheta, \varphi) \right|^2 = \left| [w_n][g_n(\vartheta, \varphi)]^T \right|^2$$

where w_n is an amplitude/phase weighting for an nth element of the circular array and $g_n(\vartheta, \varphi)$ is a complex far-field radiation in direction ϑ, φ produced by the nth element as determined by a geometrical location of the nth element with respect to a local origin for the circular array.

20. The apparatus of claim 9, wherein the first and second processors are the same processor.

21. The apparatus of claim 10, wherein the first and second processors and the memory are part of a computing device.

22. An apparatus for an antenna system, comprising:

means for receiving a plurality of signals;

means for calculating amplitude and phase corrections and amplitude and phase weights; and

means for applying amplitude and phase corrections and amplitude and phase weights to the plurality of signals.